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POWERED BACK-UP ROLL NEW TECHNOLOGY FOR PEELING VENEER
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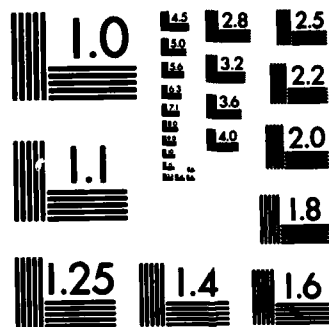
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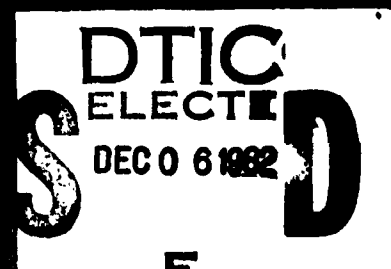
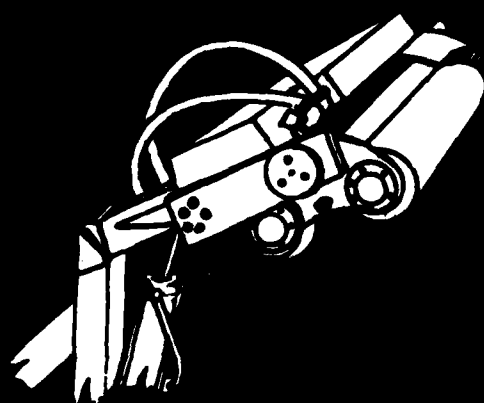
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Powered Back-up Roll—New Technology for Peeling Veneer



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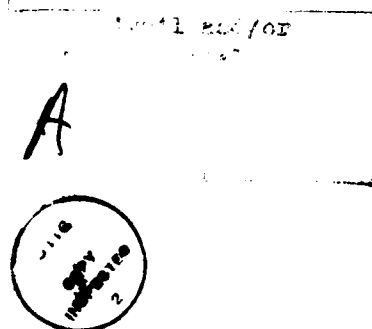
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Abstract

A powered back-up roll was designed and built for the purpose of providing auxiliary torque to a veneer bolt. Initial testing indicates that a substantial percentage of the required torque can be supplied by the powered back-up roll. This reduces the likelihood of spin-out occurring and allows a reduction in the final core size when used in conjunction with smaller chucks.



Note

This paper is the second in a series of four papers describing the FPL powered back-up roll. The other Research Papers are:

- FPL 427 Influence of Chuck Design on Spin-Out Torque in Softwood Veneer Peeling Blocks
- FPL 429 Laboratory Performance of a Powered Back-Up Roll for Peeling Veneer
- FPL 430 Industrial Performance of Powered Back-Up Roll for Peeling Veneer.

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Laboratory¹

Research
Paper
FPL 428

October 1982

Powered Back-up Roll—New Technology for Peeling Veneer

By

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Introduction

In order to develop a practical and efficient means of providing auxiliary torque to veneer bolts, a powered back-up roll (PBR) was designed and built at the Forest Products Laboratory (FPL).

This report describes the design of the PBR and discusses the test program and results obtained thus far. Initial testing demonstrates the feasibility of the PBR concept. The torque provided by the PBR was measured while peeling Douglas-fir veneer of different thicknesses. Veneer quality was not adversely affected by the new process. This new technology promises increased resource recovery and subsequent savings. Additional test results will be reported as they become available.

Background Information

The Role of Veneer in the Forest Products Industry

Veneer is considered to be one of the Nation's most valuable forest products. An estimated 700 million cubic feet of wood are consumed annually to produce veneer, most of which is used in plywood. This is equivalent to a 4,000-mile-high stack of 4 by 8 sheets.

In 1979, plywood accounted for 13 percent of the total volume of all wood products, and an even more impressive 33 percent of the total value. By comparison, lumber accounted for 76 percent of the total volume, and 60 percent of the total value of all wood products. While lumber has almost six times the volume of plywood, it has only twice the value (fig. 1).

When considering the U.S. panel products industry, plywood accounts for approximately 65 percent of the volume, and 80 percent of the value. Particleboard, medium density fiberboard (MDF), and hardboard combined account for 28 percent of the volume, but only 18 percent of the value (fig. 2). This indicates the relative value of veneer and the importance of increasing the recovery of veneer from the timber resource.

Problems Associated with Veneer Peeling

Historically, the major problems which cause reduction in veneer yield have been spin-out, large core size, and unpeelable logs.

Spin-out

This occurs when the torque required to peel a log exceeds the amount which can be transmitted by the chucks through the ends of the log. The chucks eat through the wood and spin freely without turning the log, making it unusable for further peeling. Spin-out

¹Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

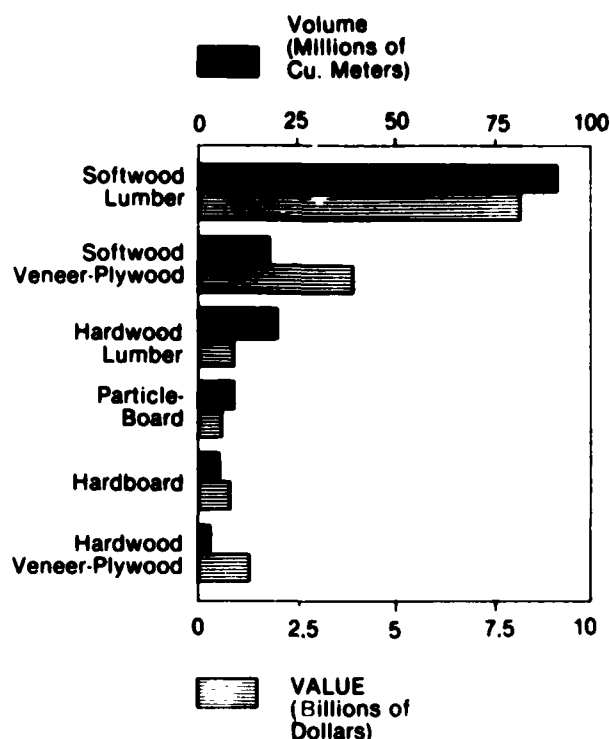


Figure 1.—Total U.S. consumption of wood products, 1979 data (includes veneered products).

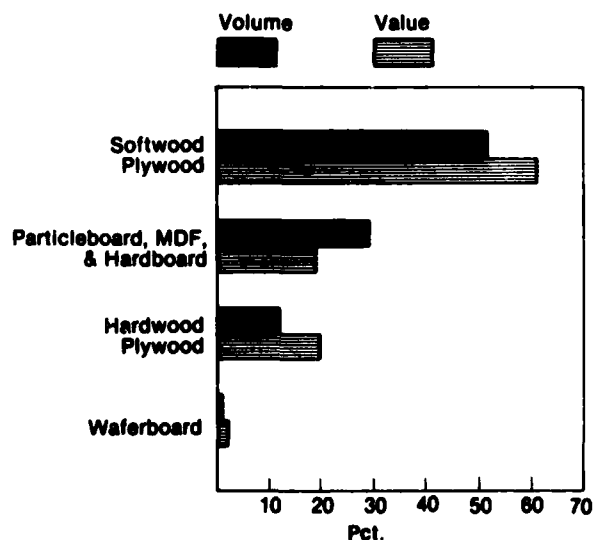


Figure 2.—U.S. panel products distribution, 1979 data.

occurs in 5 to 8 percent of all logs which are considered peelable.

There are several approaches which have been taken in an effort to solve the spin-out problem. One is to reduce the amount of torque required to peel veneer. This can be done by proper log conditioning, good lathe maintenance, and use of a modified pressure bar, such as a roller bar (1,2).² Another approach is to increase the

amount of torque which the chucks can safely transmit. This has resulted in the use of dual chucks, consisting of a large retractable outer chuck and a smaller inner chuck. Peeling of a log begins with the outer chuck, when the log is the largest and therefore requires the most torque. When the log is peeled down to a smaller diameter, the outer chuck retracts and the load is transferred to the inner chuck. Depending upon the relative size of the chucks, however, spin-out often occurs at this transition stage.

Figure 3 can be used to show how much veneer is lost when a bolt spins out. For example, if a 12-inch bolt spins out at a diameter of 8 inches, 44 percent of the wood volume remains in the core. Only 56 percent of the wood is converted to veneer. If the same 12-inch bolt is peeled down to 5 inches, only 17 percent of the wood volume remains in the core, and 83 percent has been converted to veneer.

Large Core Size

This second major problem is related to the spin-out problem. The size of the core is essentially determined by the size of the inner chuck. Core size can be reduced by using smaller chucks, but this increases the probability of a spin-out. The use of dual chucks is a compromise solution to large core size and spin-out. It reduces the chance of spin-out, while providing a smaller core than would be attainable using a single chuck. The increase in veneer yield by going to a smaller core is also shown by figure 3. New technology may make it possible to peel a bolt down to a 3-inch core, versus the standard 5 inch. For a 12-inch bolt peeled down to 3 inches, only 6 percent of the wood volume remains in the core, with 94 percent conversion into veneer. Compared to the 5-inch core, this is an increase of 11 percent in the wood volume converted to veneer. Of course, the decision to go to a smaller core would depend on the economics involved in converting a 5-inch core into additional veneer versus chips, studs, landscaping ties, etc.

Unpeelable Logs

The third major problem with conventional veneer peeling is that logs with bad centers are unpeelable or, at best, have an unacceptably high spin-out rate. These logs cannot be adequately gripped by the chucks; and as a consequence, they are relegated to sawtimber or to the chipper, or they are left in the woods. This problem represents a serious loss of a potentially valuable product.

New Technology for Peeling Veneer

The FPL has developed a PBR which promises to minimize the preceding problems. The PBR consists of a pair of hydraulically powered rollers which turn against the surface of the log and assist the lathe chucks in providing torque to the veneer bolt. A

² Italicized numbers in parentheses refer to literature cited at the end of this report.

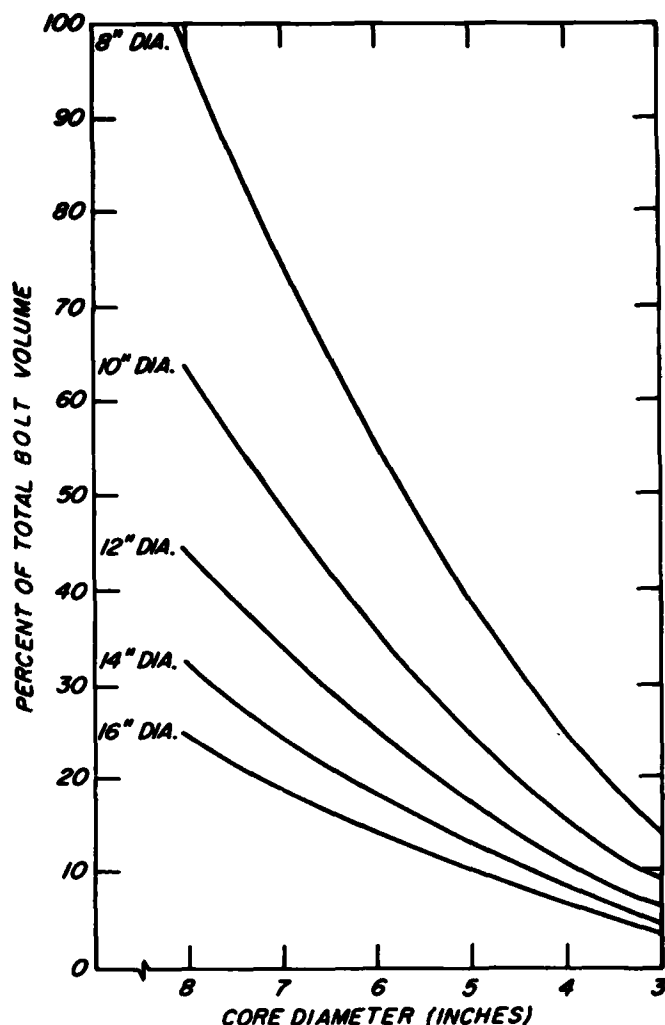


Figure 3.—Percent volume of wood remaining in peeler cores.

(M 151-018)

hydraulic cylinder holds the PBR in contact with the log at a constant force (fig. 4). Since it can provide much of the required torque, the PBR enables a log to be peeled using very small chucks. This means core size can be reduced, spinout minimized, and so-called unpeelable logs can be peeled.

Powered Back-up Roll

The general considerations for a full-size PBR are explained in the following paragraphs.

Performance Target

When work was initiated on the PBR, virtually no background information was available related to powering a veneer bolt from the surface. Some preliminary work establishing the coefficient of friction of rubber, steel, and emery cloth with green wood had been published (2). There were significant differences between conditions encountered in this previous work

and those expected in a full scale PBR. Because of these differences the results of the preliminary work could not reliably be used to estimate the amount of torque which could be transmitted to a veneer bolt through friction.

It was also difficult to determine the amount of torque required to peel veneer. Because of these factors it was difficult to assess the percentage of the required torque that would be available from the PBR. Based on conversations with veneer producers and lathe manufacturers, it was felt that if 10 percent of the total required torque could be provided by the PBR, then this would be a worthwhile achievement. While no theoretical limitations exist which limit the amount of torque that could be delivered, consideration of practical problems such as the size of the roller and hydraulic motor performance seemed to indicate that a contribution of 10 to 25 percent would be a reasonable performance target.

It was necessary to strike several compromises when establishing the design criteria for the powered back-up roll. Some of these compromises were necessitated by unique requirements imposed by the FPL veneer lathe, a 4-foot Coe A-frame model. In spite of limitations due to the use of an old lathe, the powered back-up roll was, wherever possible, designed to be compatible with modern industrial lathes and peripheral equipment. A full-size, rather than experimental scale, back-up roll was designed and built. It was felt that, by working with a full-size piece of equipment, more reliable information could be obtained about both the potential benefits and problems associated with this approach.

Two important differences between the FPL back-up roll and one intended for commercial use are the speed of operation and the method of positioning the back-up roll on the log.

Operational Speed

The FPL lathe can operate at a maximum constant speed of approximately 40 revolutions per minute (rpm). With a 36-inch-diameter log, this corresponds to a peripheral speed of 375 feet per minute (ft/min). Since the lathe operates at a constant rotational speed, the peripheral speed of the log decreases linearly with the log radius. Because commercial lathes normally maintain a constant peripheral speed, the controls for the PBR were designed to be compatible with either constant or variable peripheral speed. While the FPL lathe's maximum peripheral speed is less than 400 ft/min, the PBR was designed to be compatible with lathes operating up to 1,000 ft/min on a continuous duty cycle. Even higher speeds could be obtained with a higher capacity hydraulic supply pump.

Log Loading

The FPL lathe configuration also dictated the method by which the PBR had to be mounted to position itself on the log. The FPL PBR was mounted to a floor stand rather than the lathe itself; however, this in no way

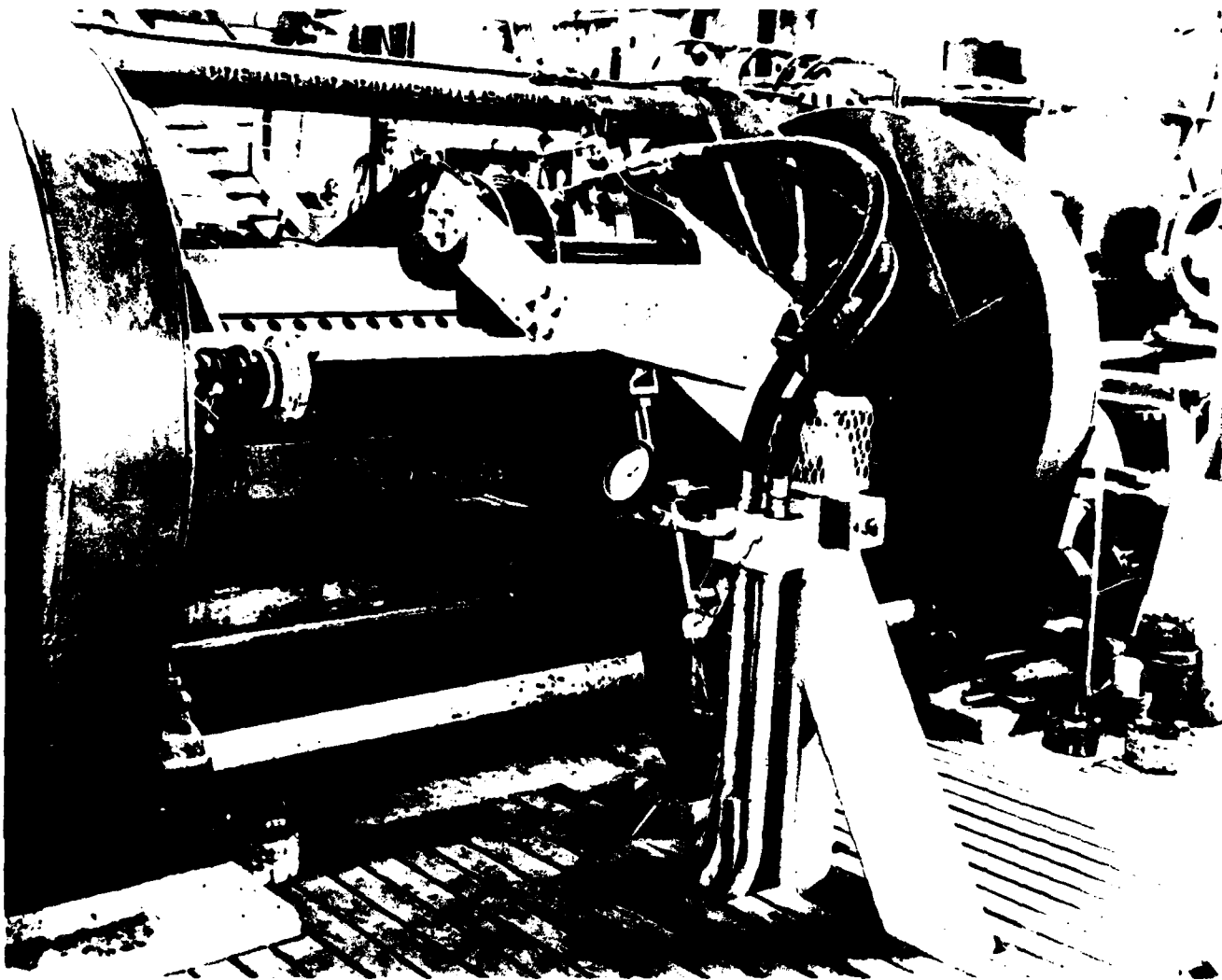


Figure 4.—FPL PBR with lathe.

(M 150 229-6)

affects the actual operation of the PBR. In industrial practice it would be mounted the same way as a conventional back-up roll so as to not interfere with normal log loading procedures.

Design Features

Supporting Frame

The back-up roller consists of two basic components, the supporting frame and roller head assembly. The supporting frame for the roller head assembly does not affect the function of the back-up roller but merely positions it on the log. A hydraulic positioning cylinder generates a normal force to provide traction between the roller and the log (fig. 5). The stand was designed to provide a 12,000-pound maximum normal force on the log when the hydraulic positioning cylinder's pressure is at its maximum of 3,000 pounds per square inch (psi). The stand is fabricated from 6-inch square tubing with a 3/8-inch wall thickness. The normal force is obtained with a 4-inch-diameter bore hydraulic cylinder,

and its magnitude is controlled by the cylinder hydraulic pressure. In the experimental prototype, this pressure is regulated by a manually operated pressure relief valve.

Roller Head Assembly

Roller Coating

The auxiliary torque is transmitted to the log using two hydraulically powered rollers. The rollers are 7-1/2-inch outside diameter (o.d.) steel tubing with a high friction coating. The thickness of the coating is 1/8 inch so that the final diameter of the rollers is 7-3/4 inches (fig. 6). The material selected for the coating was DuPont brand "Adiprene"® —a urethane rubber material. This material bridges the gap between plastics and rubbers, and is resistant to water, oil, abrasion, and high temperatures.

Common industrial applications of this material are solid industrial tires and rolls, equipment linings, and seals. It was chosen because of its relatively high

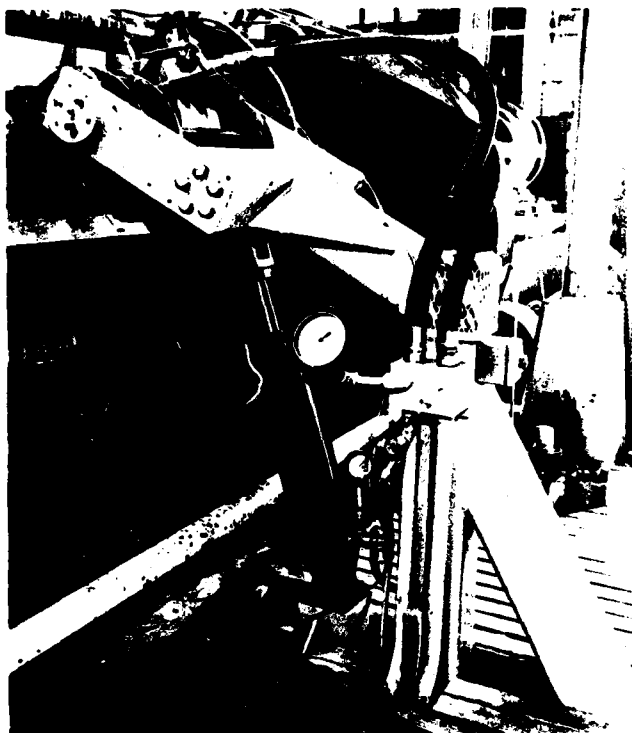


Figure 5.—FPL PBR—side view showing frame and hydraulic cylinder.

(M 150 229-10)



Figure 6.—FPL PBR rollers (from bottom).

(M 147 732-9)

values of strength, coefficient of friction, and abrasion resistance, with specific properties determined by the formulation. The compound used here was L42, with a hardness of 80 durometer A. For comparison, this is somewhat harder than a typical man's shoe heel.

The resilience of the surface coating provides a relatively large contact area or "footprint" between the rollers and the log. As the normal force increases, the contact area increases as well. The contact area also increases with log diameter. With a normal force of 3,000 pounds the total contact area ranges from approximately 12 to 24 square inches depending upon log diameter. This appears to be adequate to prevent high stress concentrations with consequent localized wood failure.

Drive Train

The rollers themselves were made from 7-5/8-inch o.d. steel tubing machined to 7-1/2 inches o.d. The length of each roller is 13-1/2 inches. For ease of removal and replacement, the rollers were attached to the shaft with locking assemblies. This allows the replacement of rollers for maintenance without removal of the gears or shafting. Both rollers are driven directly from the hydraulic motor with a gear drive. The gears have 28 teeth on a 7.0 pitch diameter, with an o.d. of 7-1/2 inches and a width of 3-1/2 inches. The driver and the driven gears are identical so that the speed ratio between the motor and rollers is 1:1. Each gear interface is capable of transmitting approximately 20 horsepower (hp) at 77 rpm (150 surface ft/min) or 40 hp at 200 rpm (400 surface ft/min). This means that each gear interface can transmit a torque of approximately 1,100 foot-pounds.

The hydraulic motor used in this application is an industrial geroler type with a displacement of 20.34 cubic inches per revolution. This motor requires a flow rate of approximately 20 gallons per minute (gpm) at 200 rpm. It is rated for continuous duty up to 2,500 psi supply pressure and up to 3,750 psi when used at a 10 percent duty cycle. The running torque at 2,500 psi is approximately 630 foot-pounds, and 950 foot-pounds at 3,750 psi (fig. 7). A standard hydraulic motor with standard hydraulic motor with internal bearings was used because of its versatility; however, similar motors are available without shaft end bearings, and they could also be used for similar installations where size is a critical factor.

Control System

Due to the experimental nature of the powered back-up roll, the system was designed to be compatible with several different control schemes. These ranged in sophistication from simple manual control of pressure to automatic control incorporating torque and speed feedback.

Manual pressure control

The simplest control system maintains the supply pressure to the motor at a relatively constant value by

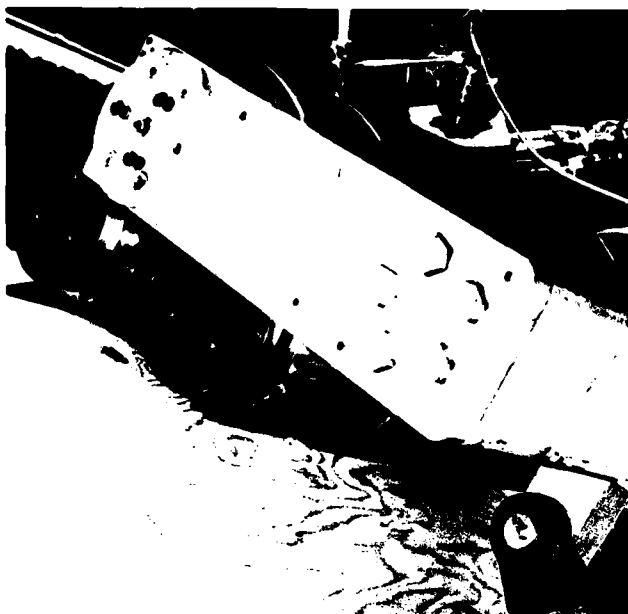


Figure 7.—Top view of motor, gears and rollers.

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using a manually operated relief valve. This valve is located at the pump and can be set to obtain a supply pressure ranging between approximately 150 to 3,000 psi. Because of dynamic factors and rapid variations in cutting forces, such as caused by knots in the log, the actual pressure drop across the motor fluctuates slightly. This observed fluctuation does not affect the performance of the prototype system. While manual pressure control is adequate for testing, it is not capable of dealing with sudden occurrences, such as the rollers slipping on the log. A more refined control system is needed for this, and is discussed later.

Automatic System

In order to provide more precise control of the system while operating, the motor torque can be controlled with a closed loop servosystem (fig. 8a and 8b). The torque is controlled by regulating the pressure drop across the motor with a servo-valve and servocontroller. Using the motor and rollers, a 200 gpm flow is needed to peel veneer at 400 ft/min, which causes a pressure drop of less than 200 psi across the valve. The pressure drop across the motor, ΔP_m , is measured by a differential pressure transducer, and is compared to the desired pressure drop, ΔP_d . The servocontroller automatically controls the valve opening to maintain the desired P_c across the motor (fig. 9). The advantages of this method over the manual system are that it responds rapidly to changes in the load, and the desired torque level can be set to preprogrammed values.

Slip Feedback Control

An additional refinement which can be added to this servosystem is speed differential or slip feedback. By comparing the peripheral speed of the rollers to the peripheral speed of the log, any slippage

between the rollers and the log can be detected. Any such slippage is undesirable, because of potential damage to the veneer and rollers, and because of reduced transmission of torque. The speed-differential signal can be used to control the servo-valve opening, and to correct the speed of the rollers in order to match the log speed. This system would work in conjunction with the servo-pressure controlled system. In normal operation, with no slip occurring, no speed differential signal is generated (fig. 10).

These control systems have undergone limited testing at the present time. Additional testing and perhaps modification may be needed to ensure their proper functioning over the intended operating range.

Position control

The PBR will allow the use of smaller chucks, and will also allow peeling down to smaller core size. This means that a commercial PBR should be capable of providing log position control, or be compatible with a separate position control system. Position control is necessary to prevent deflection of the log away from the knife as the log is peeled down to a small diameter. Position control was not incorporated into the experimental PBR; however, the hydraulic cylinder which holds the PBR in contact with the log could be used to perform this function. It should be noted that the torque required to peel veneer decreases as the log diameter decreases, thus the primary function of the PBR during peeling could change from providing torque to providing position control.

Several methods of accomplishing this position control exist. The most straightforward of these methods is to control the volume of hydraulic fluid in the cylinder with a servo-valve. The command signal would be generated from a position transducer which would indicate the position of the knife carriage. A feedback signal would be provided by a transducer which would give the location of the back-up roller. Thus a PBR could be used with a high normal force to provide maximum torque when needed, and could also be programed to provide position control when needed.

Test Program

In order to evaluate the effectiveness of the PBR, a comprehensive test program was established with objectives to:

1. Measure the torque provided by the PBR.
2. Evaluate the quality of the veneer peeled using the PBR.
3. Evaluate the roller coating material.
4. Develop criteria for optimum controls for the PBR.

These objectives are discussed in detail below. West coast Douglas-fir was used in the testing done thus far. Veneer thickness ranged from 1/32 inch to 1/10 inch.

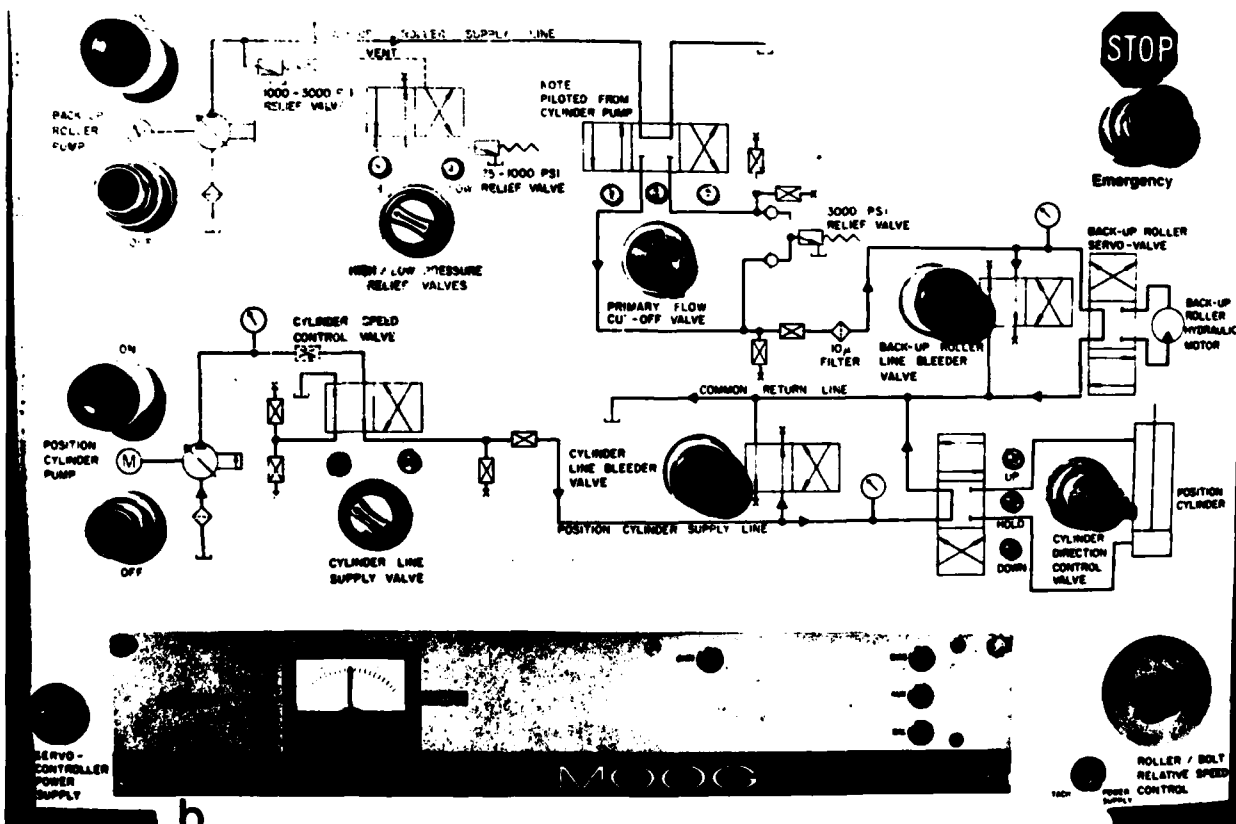
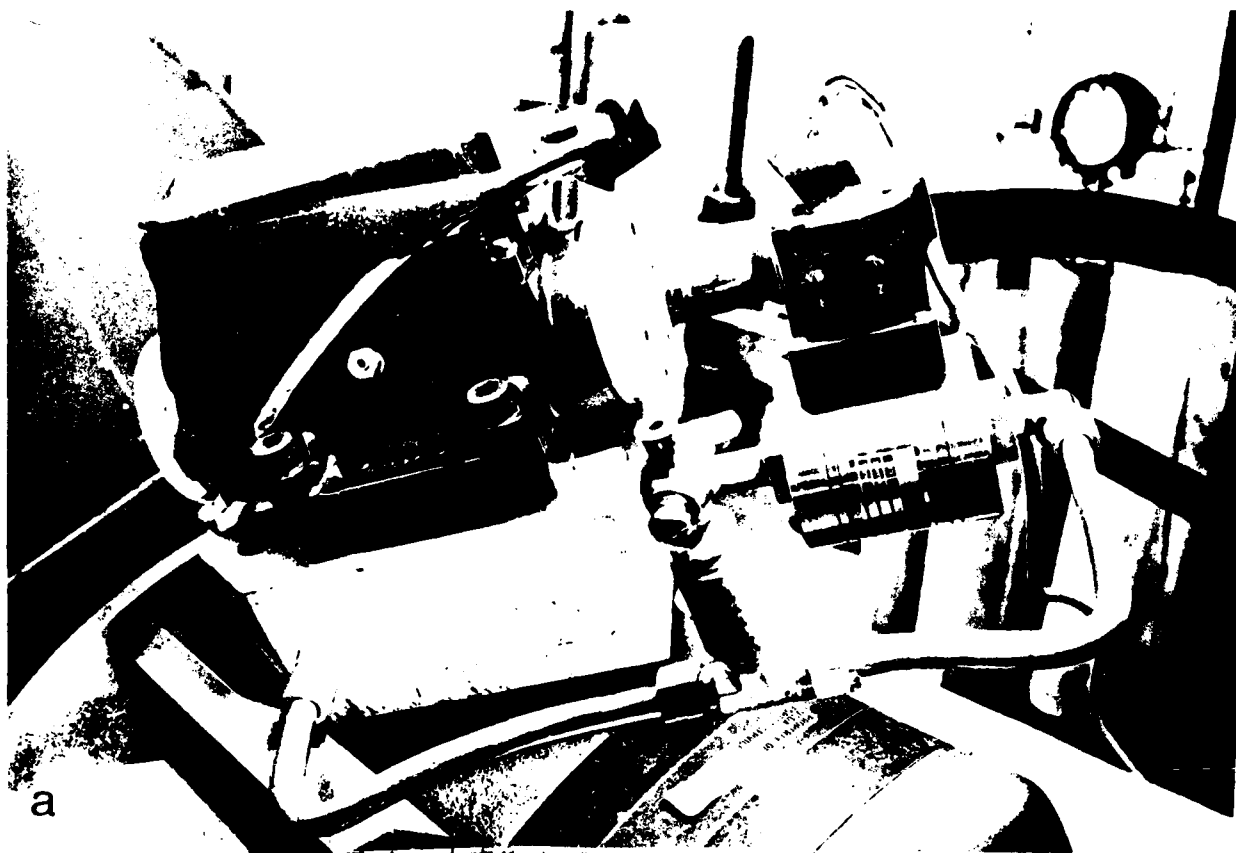


Figure 8.—(a) Servo-valve and (b) control panel.
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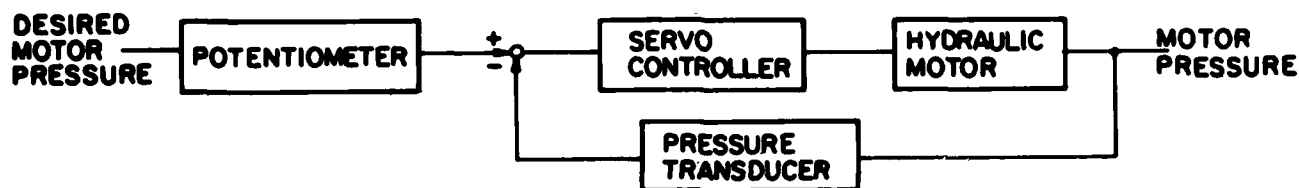


Figure 9.—Schematic of pressure control system.
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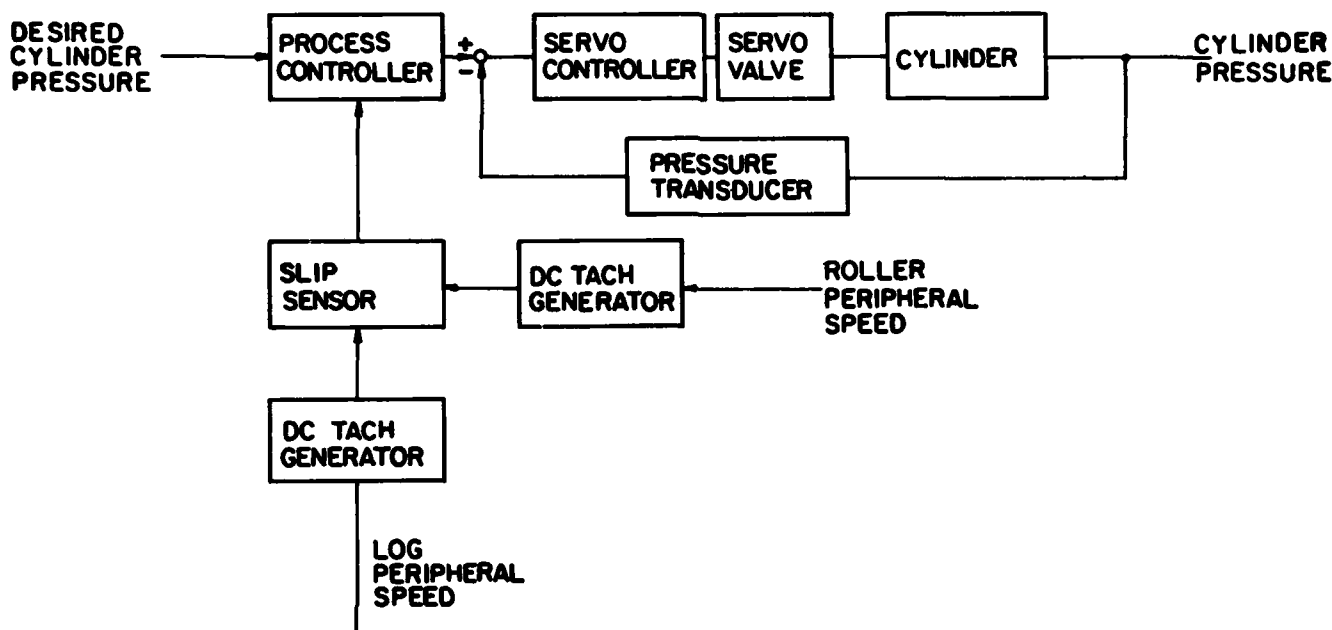


Figure 10.—Schematic of pressure control with slip control added.

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Torque Measurement

Torque was measured on the lathe using strain gages mounted on one of the spindles. Gages were installed so that they responded only to the torsional load. The log was driven by only one chuck mounted on the spindle with the strain gages. The other chuck freewheeled on bearings and provided no torque to the log, but helped hold the log in position (fig. 11).

There were two reasons why one chuck was modified for freewheeling. First, it was desirable to measure all of the torque in one location for the sake of simplicity and accuracy. In this way the output signal from the gages would be larger and less sensitive to electrical noise. Secondly, it was discovered during early peeling trials that a certain amount of "windup" occurred between the two spindles, which were not totally in phase while driving the log. This was shown by a wave pattern in the torque recording covering a period of one revolution of the log. This wave pattern disappeared when one chuck was freewheeling.

The measured torque was the torque actually provided by the lathe. A value for the PBR torque was obtained indirectly as the difference in torque readings between regular peeling and peeling with the PBR. Torque was recorded on an x-y plotter versus the radius of the log, which was measured using a position transducer which indicated the position of the knife (fig. 12).

Veneer Quality

The quality of the veneer peeled using the PBR was compared to that peeled using conventional technology. The comparison was based on uniformity of veneer thickness and on an evaluation of surface smoothness and finished appearance. The objective was to determine if the PBR caused deflection of the log and if the rollers indented or scuffed the veneer.

A sheet of veneer peeled during one revolution of the log was saved for each 1/2 inch of radius peeled off. The thickness of the sheet was measured in various



Figure 11.—Free wheel chuck with tapered roller bearing.

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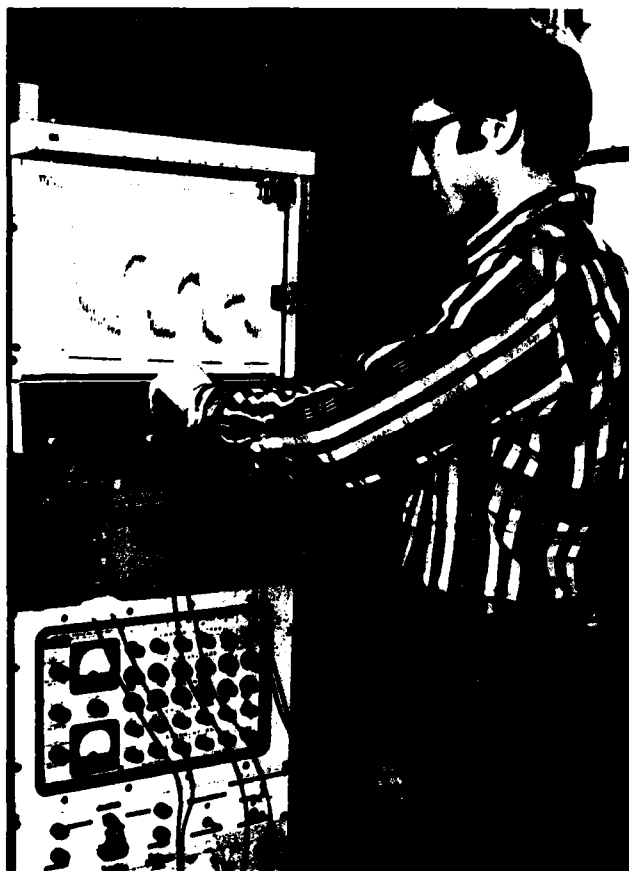


Figure 12.—Torque data recording for Douglas-fir log No. 5, 1/10-inch veneer. (X-axis is log size, increases from right to left.)

(M 150 135-8)

strategic locations. Surface smoothness and finished appearance were subjectively evaluated.

Roller Coating

During the course of testing, the roller coating properties which were evaluated included coefficient of

friction, cleanability or need to be cleaned, and durability.

Preliminary Results

The test results obtained from peeling Douglas-fir logs with the PBR were very encouraging. Tests using different species and additional thicknesses of veneer are continuing and will be reported in subsequent publications.

The powered backup roll provided 100 percent of the torque required to peel 1/32-inch and 1/16-inch veneer from 4-foot bolts, and approximately 85 percent of the torque for 1/10-inch veneer. Logs were kept green but were not heated. Veneer quality and thickness were not affected by the PBR.

The rollers were held against the log with the minimum normal force needed to prevent them from slipping on the surface of the log. The total area of the rollers in contact with the log ranged from 12 to 24 square inches, depending on log size. The roller surfaces showed no signs of wear. In several instances where the rollers did slip, the coefficient of friction was computed using the applied normal force and the instantaneous PBR torque reading. This value ranged from 0.5 to 0.8. It is believed that the lower value of the coefficient of friction was caused by the log being somewhat dried out on the surface. With a dry log, the rollers tended to load up with slivers of wood and lose their grip. This did not occur with a good green log. In any case, a nominal increase in the normal force compensated for the dried log and eliminated the tendency to slip.

The old-growth Douglas-fir logs which were peeled contained pitch pockets which occasionally fouled the rollers. This did not affect the operation of the PBR, i.e. no slip occurred, and the rollers tended to be self cleaning; but pitch buildup does appear to be a problem.

For each veneer thickness, the hydraulic pressure to the motor was manually adjusted to provide the maximum torque to the log without exceeding either the required torque or the system capacity. It was not originally believed that the PBR could provide all the torque required to peel thin veneer, but in fact it did. At some points during the peeling process, the PBR tended to overdrive the lathe, which normally operates at constant rpm, by providing excessive torque. This would need to be considered when designing a controls system for an industrial application. The results for Douglas-fir are summarized in table 1.

Figure 12 shows a typical torque trace which was obtained during testing. For any given log, the method of peeling alternated back and forth between regular and PBR assisted. The upper traces indicate the required lathe torque for regular peeling, and the lower traces show the required torque when using the PBR.

Table 1.—Powered back-up roll performance, Douglas-fir, unheated

Log diameter	Veneer thickness	Torque provided by PBR	Roller/force against log	Hydraulic pressure to motor
In.	In.	Pct	Lb	Psi
24	1/32	100	2,100	1,500
24	1/16	100	2,500	1,500
24	1/10	85	2,900	2,500

The required lathe torque was reduced by the amount indicated by the distance between the upper and lower traces. This is the contribution of the PBR. The traces shown are not smooth curves. They have peaks caused by knots which required more torque than clear wood. These peak torque values as well as the average values are reduced by the amount contributed by the PBR.

Future Work

When the current test program is completed, several new studies involving innovative processing will be undertaken. The first of these, and the most ambitious, will explore the possibility of peeling veneer without chucks driving the log by providing all of the torque

with the PBR. This would require two freewheeling chucks, and an independent means of advancing the knife according to the rotational speed of the log. Control systems development will play a large part in this study.

Another planned study would deal with peeling thick veneer, from 3/16 inch and up. This would require operating the PBR at maximum design pressure; and therefore, the study would be done toward the end of all planned work in the event of any operational difficulties. A ready means of peeling thick veneer could spur the development of new veneer products, and thus reinforce the already important role that veneer plays in the forest products industry.

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U.S. Forest Products Laboratory

Powered Back-up Roll—New Technology for Peeling Veneer, by
Frank J. Fronczak and Stephen P. Loehnertz, Madison, Wis., FPL 1982.

11 p. (USDA For. Serv. Research Paper FPL 428).

Describes the design of the powered back-up roll and discusses
the test program and results obtained. Initial testing demonstrates
feasibility of PBR concept.

Keywords: auxiliary torque, veneer bolts, veneer quality, resource
recovery, veneer yield, spin-out, log peeling, chucks, core size, rollers,
log position control.

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